

A MARINE AQUARIUM.



BY

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A MARINE AQUARIUM.*

BY PHILIP HENRY GOSSE, F.R.S.

Since you wish to know some details of the construction and working of my new Marine Tank, I send you the following notes. In the spring of 1876, I determined to erect an Aquarium, the water of which should be in constant circulation; and I decided to adopt the plan of the Crystal Palace Aquarium, viz., that in which the ratio of the water in the show-tank to the water in reserve unseen, is as 1 to 5.

My old kind friend, Mr. W. Alford Lloyd, contemporary and fellow labourer from the first in aquarian development, gave me the invaluable aid of his counsel in every step of the work; ever suggesting and improving, as it went on, with a zeal which could not have been exceeded if the scheme had been his own. The mechanical contrivances and fittings were supplied by the eminent engineers, Messrs. Leete, Edwards, and Norman, to whose courtesy, skill, and thoroughness of work, I bear willing witness. The Tanks were made and put together, and the whole erected and set a-going, by mechanics of the place.

In the servants' front of my house was an apartment used as a lumber room, whose floor was about 12 feet from the ground, with a window looking N.W. This window I took out, and enlarged, for the reception of the show-tank (henceforth to be distinctively the "Tank"); and the room itself was dubbed the "Aquarium."

The window looked upon a yard, across which was an out-house used as a coal-cellar. The farther corner of this house I excavated, for the reception of a strong slate tank (the "Reservoir"), which was sunk so that its top was level with the ground.

Another slate tank (the "Cistern") was placed within the roof, immediately over the Tank, resting partly on the summit of the stone wall of the house, and partly on the rafters, which were strengthened for the purpose.

These three vessels were made of squared slabs of best slate, varying in thickness from $1\frac{1}{2}$ in. (base) to 1 in. (sides), which were bolted together with iron rods, tightened by screws and nuts at the ends. All the internal angles were filled with Portland cement. The Tank had that side which faced the interior of the room, made of $\frac{1}{2}$ in. plate-glass.

* In a letter to Mr. William R. Hughes, F.L.S., Birmingham.

The dimensions and capacities of these vessels were as follows:—Tank 42in. long, 18in. wide, 18in. deep, in the clear; each inch of depth equal to 2·73 gallons; 49 gallons in total. Reservoir 62 $\frac{3}{4}$ in. long, 35 $\frac{1}{4}$ in. wide, 26 $\frac{1}{4}$ in. deep, each inch equal to 8 gallons; 210 gallons in total. Cistern 34in. long, 34in. wide, 27in. deep, holding 112 gallons.

The Reservoir in the cellar was first put together, sunk in place, proved water tight, and the earth rammed around it, in May. Early in June a water cart, viz., a hogshead on wheels, was filled thrice with the crystal water of Oddicombe shingle-beach, and emptied by a hose into it, giving me 210 gallons of pure sea-water in my Reservoir, which was protected from dust by a strong and tight cover of wood, divided and hinged in the middle for convenience of examination.

Early in September the whole apparatus of pump, pipes, valves, &c., arrived from the engineers, to be described in detail; and immediately the masonry of the house was opened to receive the Cistern and the Tank. A large opening having been made in the gable above the window, two cross-joists of 4in. square deal were inserted in the ceiling from the gable-wall to the centre beam. The base of the Cistern was got up, and laid *in situ*, square and level, save a $\frac{1}{2}$ in. inclination to S.W., that it might be emptyable to the last drop. A hole was now drilled in this S.W. part of the base, for insertion of the *jet pipe*, over the Tank; and another on the N.E. side, for insertion of the *warning pipe*. The sides of the Cistern were then set-up in Portland cement, bolted together, and smoothed within and without.

The base and sides of the Tank were put into place, first *tentatively*, until the Cistern, and the pump with its pipes, were adjusted; and then *finally*, cemented and bolted; and the plate-glass front was bedded in lead putty in its grooves, well worked in, and smoothed off. Before this last, however, the siphonal apparatus was prepared and affixed, which will presently be described.

Thus, then, the three continent vessels were in place, and appeared perfect. But these alone were of little avail. A large volume of sea-water, indeed, had been lying for more than three months quiescent in the lowest, dark and cool below the earth-level, and still brilliantly pure, as a tumblerful dipped out proved. But we wanted to lift this water out of the Reservoir into the Cistern in the roof, to transmit it thence into the Tank, and thence again into the Reservoir; and to do this perpetually, without an instant's intermission, day and night, by a constant circular current.

The apparatus by which this was effected I must now proceed to describe.

1.—The Pump. This was an ordinary lift-pump, of great strength, and great accuracy of workmanship, the materials of which were steel, vulcanite and glass. The last-named material was strongly recommended to me by Mr. Lloyd, for the pump barrel; a cylinder of plate-glass turned and polished within and without, so as to be mathematically true, with turned and polished balls of glass to act as valves. These can be obtained only from one house in England, that of Chedghey, in the Borough, maker and patentee. They are in demand for vinegar and

other acid-works, for the same reason that made one valuable to me. Mr. Lloyd first procured one from the maker, with much personal trouble and difficulty, so greatly does the demand exceed the supply ;—and then, with characteristic kindness, compelled me to accept it as his gift. It is 3in. in diameter internally, and 8in. high ; has a capacity of $1\frac{1}{2}$ pint, when making its available stroke of 6in., after allowing for the thickness of the piston ; and it weighs 4lbs. 12oz. For this the engineers made two metal caps, one above and one below ; which were then joined by two metal rods parallel to the barrel, screwed and nutted to the caps. To avoid oscillation in pumping, the fulcrum was fixed, independent of the barrel, to the stout wooden plank which carried the pump ; and a “fork and cradle” motion insured parallelism of the piston-rod by means of a “guide,” also fixed independently to the plank. This relieves the barrel from all side strains, which might break it. The piston-rod was of polished steel ; the fulcrum (handle) and loop of iron.

This pump, firmly affixed to a stout plank, we set upright against the wall of the Aquarium, immediately on the right hand of the Tank ; and at such a height that the surface of the full Tank was level with the mid-height of the barrel. Then we firmly bolted the plank to one of the rafters of the house.

2.—The Supply-pipes. But the pump was to be a forcing pump (“lift and drive”), and not merely a lifting pump. Therefore, the valve ball, descending by the up-stroke of the fulcrum, opens a chamber, in which there is a second ball. This is so far lifted, by the in-forced water from the barrel, as to open a pipe (the Cistern supply-pipe), which proceeding up through the ceiling delivers it into the Cistern above. The Pump supply-pipe, a stout tube of vulcanite, commencing 6in. from the bottom of the Reservoir, passing over its edge, under the surface of the soil, across the yard, through the foundation of the house, up the interior of the wall, through the ceiling of the ground-floor, joins the bottom of the pump-barrel ; and, at every down-stroke of the handle, delivers one and a-half pint of water from the reservoir into the glass barrel ; which water is, the very next moment, by the up-stroke, poured into the Cistern above. Into the perforate bottom of the Cistern, another tube (the jet-pipe) is screwed ; which, proceeding vertically downward to within close proximity to the surface of the Tank, allows the water to descend by its own gravity, and fill the Tank.

The force and rapidity, with which this descending column of water shall enter, are regulated by a series of jets, or thimbles of vulcanite, in all which a screw is cut with one common thread, to screw on the extremity of the jet-pipe. These are pierced with a minute hole, very truly drilled, whose bore is different in each, according to the special requirement of the Tank.

3.—The Waste-pipe. A vulcanite pipe leaves the right side of the Tank near the front, and carries away the spare water to the Reservoir, passing down alongside of the Pump-supply-pipe. The position of its exit, about 2in. from the margin, of course determines the level at which the water always stands in the Tank. It was at first proposed that this should be a simple pipe, screwed into a hole in the side ; but this would

have carried off only the surface-water. To make the circulation complete, I chose to take it from a point very near the bottom. To avoid the uncouth appearance of a pipe, however, Mr. Lloyd devised the following contrivance. A slab of slate, $2\frac{1}{2}$ in. wide, 1 in. thick, and as high as the Tank, has a semi-cylindrical groove gouged out of one face, but not reaching quite so far as either end. Its upper end meets the hole in the side of the Tank at the surface, while its lower end meets a similar hole bored through the slab itself. The slab being firmly cemented in place, the water in the Tank, entering through the horizontal hole, rises in the hidden groove (now become a tube) till it reaches the exit-hole in the Tank, when it begins, and continues, to trickle out through the waste-pipe. Thus the Tank can never overflow, unless the inflow be more copious than the bore of the waste-pipe can carry off, or this pipe become choked. To meet the latter peril, a strainer was cemented around the interior orifice, in this form: suppose a shallow box of vulcanite, to which there is no cover; the bottom drilled with a number of holes $\frac{1}{2}$ in. wide. This is set up on one of its sides, on the Tank-bottom, with its lidless top in contact with the lower part of the slab, the perforated bottom (now become the side) facing the interior of the Tank. It is not cemented, but merely kept in position by a heavy piece of the rock-work; because I need sometimes to remove it, in order to cleanse the straining-holes. By this contrivance (while the water can freely percolate and escape), since nothing larger than the pin-holes can pass, the waste-pipe, which is of 1 in. bore, clear, can never become choked.

4.—The Siphon. It was judged desirable to have the power of lowering the surface in the Tank, and even of emptying it of water, at pleasure, without dipping. For this object the waste-pipe was cleverly turned into a Siphon, in this wise. The waste-pipe, after leaving the Tank, runs horizontally for a foot, before it reaches the pump-plank, and turns to the perpendicular. In the midst of this space a stop-cock of vulcanite is inserted, which ordinarily is left open, and serves as an air-vent. But, if I wish to draw off the water from the Tank, I take the tip of the stop-cock into my mouth, and suck strongly, till the salt water comes rushing up. This should be sufficient; but in practice I find it needful to suck such a mouthful thrice at least, before the up-current of water is strong enough to pour continuously, which is manifest to the ear, as it roars down the perpendicular waste-pipe. I have carefully to close the stop-cock with my fingers at each suck, before I withdraw my mouth; or the vacuum, in part formed, would be again destroyed. The water sucked into my mouth I instantly discharge into the Tank at each effort. When the current is set up, the surface in the Tank is seen rapidly to descend, until it is as low as I wish; when, the opening of the stop-cock destroying the vacuum, the outflow instantly ceases; and the jet-pipe in due course refills it.

5.—The Warning-pipe. In pumping, the Cistern which we are filling is out of sight in the roof above. In order to know when it is full, that we may not allow it to overflow, a small pipe is inserted into the side of the Cistern, an inch below the brim; which, leading down through the ceiling, ends at a few inches over the surface of the Tank.

This is in sight of the person who is pumping, who cannot help hearing the babble of the stream, and seeing its sparkle, as it comes suddenly pouring down the warning-pipe; and he makes not a single stroke more.

These were, I think, all the essentials to the working of the scheme; but one or two additions were subsequently made, which I will describe. The jet thimbles could never be removed or replaced, without causing an annoying splash of water all around one's person and the furniture. To obviate this I had a vulcanite stop-cock inserted into the jet pipe, just above the jet. Thus I could close the pipe, before I unscrewed the jet; and I had now no more splashing. I have found this stop-cock useful in another way. When I siphon-off the water with the object of getting rid of the impalpable organic mud and humus, which commonly accumulates on the bottom, I remove the jet, and allow the jet-pipe to pour down its vertical torrent in full force. Thus all the moveable matters held in suspension, are whirled about; and very many of them are carried, in the siphon, down the waste-pipe to the Reservoir; where they settle quietly on the bottom, the organic parts dissolve, and the inorganic slowly accumulate in a thin pellicle on the bottom, requiring to be cleaned out, perhaps in a dozen years hence.

Although the sea-water originally put into the Reservoir was brilliantly clear and pure, and the wooden lid was made to fit close, we yet thought it prudent to guard against the possibility of extraneous matters being drawn into the supply-pipe, during the pumping, and so choking it. Accordingly a tight bell-shaped box of vulcanite was made to screw on to the bottom of the supply-pipe, about 6in. from the floor of the Reservoir. The bottom and sides of this box were drilled with many $\frac{1}{8}$ in. holes; so that it serves as a strainer, like that at the bottom of the waste-pipe.

The pipes were all made in lengths, with the requisite angles and connections; and were sent from London, carefully numbered, according to copious working-drawings. No bend can in the least degree be changed, vulcanite being inflexible and brittle. Every piece was fitted and screwed to its fellow, and "payed" with red-lead; some of the joints being also "served" with muslin. The lengths beneath the surface of the yard were carefully rammed with earth; and those which passed up the house-wall were secured to the joist by semi-circles of iron; and then inclosed in a narrow box of board, for facility of examination in case of need. The new window sash was now hung on hinges from the upper frame, and opened outward, to different degrees, by graduated metal quadrants, above the Tank; the area, much wider than originally, was made a bay-form recess, which allowed of a little useful angle on each side of the Tank. The pump, the pipes, the slate of the tank, were all painted black; an ornamental rim of polished Spanish mahogany was made to sit on the edge of the tank; a curtain was hung to conceal the pump; and the room generally made presentable.

By the end of September the whole was in place, and water was admitted into the Tank. Not till the last of October, however, were organisms admitted, in the forms of growing Algæ and Fishes. For it must not be supposed that all went quite smooth. The pump would not

draw at first ; we found that the pipes leaked, and would not deliver, till we had had much labour. Then the pump would "go back ;" the water retiring from the barrel sooner or later, after the pumping had ceased ; so that sometimes it required more than a hundred strokes of the handle, before the water would rise. This difficulty still continues, in a mitigated form ; it is the only one which we have never quite overcome. Then the siphon would not act at all for some time ; but, after several months, one day, quite suddenly and unexpectedly, it acted perfectly, and has gone well ever since.

As soon as we were in regular work, I found that my supply of water was inadequate. Some had been wasted, too ; some had leaked in the imperfect fitting of the pipes' joints. Accordingly a further quantity was brought up, which made my stock as follows:—Reservoir, 180 gallons ; Cistern, 60 ; Tank, 40 ; equal to 280 gallons in all. And this quantity has never since needed to be replenished. Its quality seems to have steadily improved. Clear and bright as it was at first, and faultless as it seemed for the sustentation of animal life ; it is very perceptibly better now. However it be explained, many creatures that would not live more than a few weeks, or even days, a year ago, now continue without difficulty, often coming into sight months after their introduction, in full health and beauty.

The manipulation is as regular as clock-work. On Tuesday, Thursday, and Saturday evenings, my servant pumps till the warning-pipe streams, averaging some 675 strokes. If the larger-bored jets are on, there must be supplementary pumping in the intercalated days, to a varying amount. For Fishes and the higher Crustacea, &c., we find the fuller supply of jet No. 1 requisite, and this profusion takes at least 250 strokes on each of the intercalated days. The total of 675 strokes is performed in about half an hour.

The jets I use are four ; of which the orifices, perfectly true and round, graduate from the thickness of a lady's medium pin (No. 1) to that of a cambric needle, (No. 4). With No. 1, 18 pump strokes deliver an hour's supply of water into the Tank ; with No. 2, about 10 strokes ; with No. 3, 5 strokes ; and with No. 4, about $3\frac{1}{4}$ strokes. The orifice of each jet is just an inch from the surface of the Tank. A white cloud of dust-like air-bubbles is driven perpendicularly downward (about a foot with No. 1), after which they can still be followed, with a lens, careering to every part of the Tank.

This communication has already reached a length, which I greatly fear will be considered tedious. I will not then attempt to narrate my experience, as a Naturalist, in the use of the Aquarium for upwards of two years. Suffice it to say, it has been a great success ; and has amply proved the value of the principle of its construction, viz., perpetual circulation, with a large reserve of water. One point I will add, which may interest some :—The total cost was covered by £60.

Sandhurst, Torquay, Nov. 20, 1878. *Q*